^{1}H MRS as evaluation tool of the effects of β-alanine supplementation on the muscle carnosine content in soleus and gastrocnemius of 400m sprinters

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Introduction:

Carnosine (β-alanyl-L-histidine) is a dipeptide that is present in both brain and skeletal muscle of humans and various animals and is suggested to play a buffering role in the physiological pH range during skeletal muscle contractions [1]. Studies have shown that ingestion of β-alanine, the rate-limiting precursor of carnosine, elevates the carnosine content in skeletal muscle in untrained volunteers [2]. In this study the first aim was to evaluate the effects of oral β-alanine supplementation on the calf muscle carnosine content of 400m sprinters by proton magnetic resonance spectroscopy (^{1}H MRS). This technique can be used for the *in vivo* detection and absolute quantification of carnosine in human calf muscle and provides a valuable non-invasive alternative to the muscle biopsy technique. The imidazole protons of the histidine subunit of carnosine are visible as well-discernible resonances at 7 and 8 ppm, downfield of the water resonance peak [3].

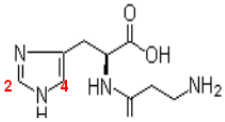

Figure 1: carnosine

Materials and Methods:

Fifteen male track-and-field athletes with a personal record on 400m below 52s were included in the placebo-controlled double-blind study. Subjects were supplemented orally for 4 weeks with 4.8g/day placebo (maltodextrine) or β-alanine (Carnosyn, NAI, San Marcos, USA). MRS measurements were performed before and after supplementation on a 3 T whole body MRI scanner (Magnetom Trio Tim, Siemens AG Medical Solutions, Erlangen, Germany) equipped with a knee coil. Spectra were acquired using single voxel point-resolved spectroscopy (PRESS) localisation with TR/TE = 2000/30 ms, VOI = (12x30x40)mm^3, NEX = 256, 1024 data points and a spectral width of 1200 Hz. Total acquisition time was 8.4 minutes. Absolute quantification of muscle carnosine was determined by the C2-H imidazole peak of the spectrum, acquired in both soleus and gastrocnemius of the calf muscle. As a reference a 500ml spherical phantom containing a 50 mM carnosine (Sigma Aldrich) solution was used.

Results:

Prior to supplementation, the absolute carnosine concentration in soleus was 7.25 ± 1.47 and 7.76 ± 1.36 mM in the placebo and β-alanine group, respectively. Following supplementation, the concentration in soleus increased by 47% ($p<0.001$) in the β-alanine group to 11.39 ± 1.38 mM, whereas there was no significant increase (+8%, $p=0.41$) in the placebo group (7.85 ± 1.04 mM). In gastrocnemius, the initial carnosine concentration was ~25% higher than in soleus ($p<0.05$), being 8.56 ± 1.88 and 10.16 ± 1.91 mM in the placebo and β-alanine group, respectively. After supplementation, the concentration in gastrocnemius increased up to 37% ($p<0.0001$) to 13.9 ± 2.66 mM and 16% ($p=0.005$) to 9.9 ± 1.3 mM in the β-alanine group and the placebo group, respectively, with a significantly larger increase observed in the former group.

Discussion:

In conclusion, we can state that ^{1}H MRS can be used to quantify the human muscle carnosine content in a non-invasive way. Furthermore, the muscle carnosine content can be substantially elevated by oral β-alanine supplementation in 400m sprinters. The moderate rise in gastrocnemius carnosine content in the placebo group suggests that also training per se can induce muscle carnosine loading.

References:

[1] Bate Smith *J Physiol (Lond)* 92:336-43, 1938
[2] Harris *Amino Acids* 30:279-89, 2006
[3] Derave *J Appl Physiol* 103:1736-1743, 2007

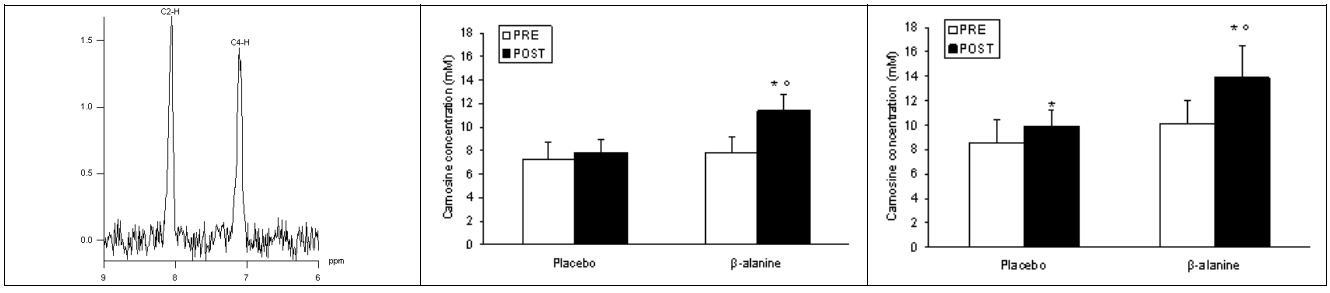

Figure 2: Spectrum of the imidazole protons of carnosine at 7 and 8 ppm; the muscle carnosine concentration (mM) in soleus (left) and gastrocnemius (right) before and after 4 weeks of supplementation of placebo or β-alanine.